



PATENT COOPERATION TREATY
PCT
INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY
(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

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|---|--|--|----------------------|
| Applicant's or agent's file reference 80449 WO | FOR FURTHER ACTION | | See Form PCT/PEA/416 |
| International application No. PCT/EP2004/001870 | International filing date (<i>day/month/year</i>) 25.02.2004 | Priority date (<i>day/month/year</i>) 08.12.2003 | |
| International Patent Classification (IPC) or national classification and IPC INV. C01G39/00 C01G41/00 C01G1/00 | | | |
| Applicant JOZEF STEFAN INSTITUTE | | | |
| <p>1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.</p> <p>2. This REPORT consists of a total of 5 sheets, including this cover sheet.</p> <p>3. This report is also accompanied by ANNEXES, comprising:</p> <p style="margin-left: 20px;">a. <input checked="" type="checkbox"/> <i>sent to the applicant and to the International Bureau</i>) a total of 5 sheets, as follows:</p> <p style="margin-left: 40px;"><input type="checkbox"/> sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).</p> <p style="margin-left: 40px;"><input type="checkbox"/> sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.</p> <p style="margin-left: 20px;">b. <input type="checkbox"/> (<i>sent to the International Bureau only</i>) a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or tables related thereto, in electronic form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).</p> | | | |
| <p>4. This report contains indications relating to the following items:</p> <p><input checked="" type="checkbox"/> Box No. I Basis of the report</p> <p><input type="checkbox"/> Box No. II Priority</p> <p><input type="checkbox"/> Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability</p> <p><input type="checkbox"/> Box No. IV Lack of unity of invention</p> <p><input checked="" type="checkbox"/> Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement</p> <p><input type="checkbox"/> Box No. VI Certain documents cited</p> <p><input type="checkbox"/> Box No. VII Certain defects in the international application</p> <p><input type="checkbox"/> Box No. VIII Certain observations on the international application</p> | | | |
| Date of submission of the demand 13.06.2005 | | Date of completion of this report 28.03.2006 | |
| Name and mailing address of the international preliminary examining authority:  European Patent Office - P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk - Pays Bas Tel. +31 70 340 - 2040 Tx: 31 651 epo nl Fax: +31 70 340 - 3016 | | Authorized officer Siebel, E Telephone No. +31 70 340-1016  | |

10/582173

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/EP2004/001870

IA20 Rec'd PCT/PTO 08 JUN 2006

Box No. I Basis of the report

1. With regard to the **language**, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.
 - ☐ This report is based on translations from the original language into the following language, which is the language of a translation furnished for the purposes of:
 - ☐ international search (under Rules 12.3 and 23.1(b))
 - ☐ publication of the international application (under Rule 12.4)
 - ☐ international preliminary examination (under Rules 55.2 and/or 55.3)
2. With regard to the **elements*** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report):*

Description, Pages

1-22 as originally filed

Claims, Numbers

1-31 received on 23.11.2004 with letter of 23.11.2004

Drawings, Sheets

1-12 as originally filed

- ☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing

3. ☐ The amendments have resulted in the cancellation of:
 - ☐ the description, pages
 - ☐ the claims, Nos.
 - ☐ the drawings, sheets/figs
 - ☐ the sequence listing (*specify*):
 - ☐ any table(s) related to sequence listing (*specify*):
4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).
 - ☐ the description, pages
 - ☐ the claims, Nos.
 - ☐ the drawings, sheets/figs
 - ☐ the sequence listing (*specify*):
 - ☐ any table(s) related to sequence listing (*specify*):

* If item 4 applies, some or all of these sheets may be marked "superseded."

**INTERNATIONAL PRELIMINARY REPORT
ON PATENTABILITY**

International application No.
PCT/EP2004/001870

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

| | | |
|-------------------------------|-------------|------|
| Novelty (N) | Yes: Claims | 1-33 |
| | No: Claims | |
| Inventive step (IS) | Yes: Claims | 1-33 |
| | No: Claims | |
| Industrial applicability (IA) | Yes: Claims | 1-33 |
| | No: Claims | |

2. Citations and explanations (Rule 70.7):

see separate sheet

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INTERNATIONAL PRELIMINARY
REPORT ON PATENTABILITY
(SEPARATE SHEET)

10/582173
AP20 Rec'd PCT/PTO 08 JUN 2006
International application No.

PCT/EP2004/001870

Re Item V.

1 The following documents are referred to in this communication:

- D1: DATABASE CHEMABS CHEMICAL ABSTRACTS SERVICE, COLUMBUS, OHIO, US; AN 99:46283 CA 12 May 1984 (1984-05-12), C. PERRIN, M. SERGENT, J.C. PILET, F. LE TRAON, A. LE TRAON: "Structure-property relations in new Mo(III) and Mo(II) chalcogenides with Mo₄ and Mo₆ clusters" XP002283920
- D2: DATABASE CHEMICAL ABSTRACTS CHEMICAL ABSTRACTS SERVICE, COLUMBUS, OHIO, US; AN 98:170737 12 May 1984 (1984-05-12), C. PERRIN, M. POTEL, M. SERGENT: "Molybdenum bromide sulfide (Mo₆Br₆S₃): a new two-dimensional compound with octahedral Mo₆-Clusters" XP002283921
- D3: M. REMSKAR, . MRZEL, R. SANJINES, H. COHEN, F. LÉVY: "Metallic Sub-Nanometer MoS(2-x)I(y) Nanotubes" ADVANCED MATERIAL, vol. 15, no. 3, 2003, pages 237-240, XP002283919

NOVELTY :

1. The document D1 discloses the compound Mo₆S₃Br₆ (x+y=9), the structure comprising Mo₆-Clusters and [Mo₆S₄Br₄]-units. However, as D2 shows, the structure of Mo₆S₃Br₆ is a layered (i.e. two dimensional) one build up by [Mo₆L₈]-Units.

The subject-matter of claim 1 is therefore new (Article 33(2) PCT).

INVENTIVE STEP :

- 2.1. The document D1 is regarded as being the closest prior art to the subject-matter of claim 1, and discloses the compound Mo₆S₃Br₆ (x+y=9), which, as it is proven by D2, has a layered structure, from which the subject-matter of claim 1 differs in that the compounds are grown in form of nanowires, nanoropes, nanorods, whiskers or needles.
- 2.2. The problem to be solved by the present invention can be considered as to provide compounds of the formula Mo₆S_yI_z, 8.2<y+z<10 for use in nano-electrochemical

devices or sensors.

- 2.3. The solution proposed in claim 1 of the present application can be considered as involving an inventive step (Art. 33(3) PCT) for the following reasons :
- 2.4. D1 teaches, that a composition $\text{Mo}_6\text{S}_y\text{I}_z$, ($x+y=10$ or 12) cristallizes in form of extremely fragile needles, which due to their fragility would not be suitable for use in nano-electrochemical devices or sensors, even if they would have the necessary electrochemical properties. Document D3 discloses a $\text{Mo}_6\text{S}_{2-y}\text{I}_z$ with a nanotube structure, however, the stoichiometry is different to the one claimed in the present application.
Therefore it appears, that the cited prior art does not give a hint or an advice of providing a compound $\text{Mo}_6\text{S}_y\text{I}_z$, $8.2 < y+z < 10$ with a nanowire or nanotube structure suitable for use in a nano-electrochemical devices and sensors.
3. Claims 2-33 are dependent on or refer to claim 1 and as such also meet the requirements of the PCT with respect to novelty and inventive step.

Claims

1. A material of the general formula $M_6C_yH_z$, wherein M ^{is molybdenum,} ~~designates a transition metal~~, C designates a chalcogen, H designates a halogen, and wherein y and z may be of from 0 to 10 such that $8.2 < y+z < 10$, grown in the form of nanowires, nano-ropes, nanorods, whiskers or needles and obtainable by a process comprising the steps of mixing the constituent elements in the desired mass ratio, placing them in an appropriate container, evacuating the container and heating it to a temperature above 1000 °C for a predetermined length of time.
- ~~2. The material according to claim 1, wherein M is a transition metal selected from the group consisting of Mo, W, V, Ti, Ta, Nb, Zn, Hf, Re and Ru.~~
3. The material according to claim 1 or 2, wherein M represents a mixture of two or more ~~transition metals~~.
- ^{claim 1}
2.4. The material according to ~~preceding claims~~, wherein C = S, Se, Te.
- 3.8. The material according to preceding claims, wherein C represents a mixture of two or more chalcogens.
- 4.8. The material according any of the preceding claims, wherein the halogen H= I, Br, Cl or F.
- 5.7. The material according to preceding claims, wherein H represents a mixture of two or more halogens.
- 6.8. The material according to any of the preceding claims, wherein $0 < y < 10$, $0 < z < 10$ and $8.2 \leq y+z < 10$.

~~7. 8.~~ The material according to any of the preceding claims, wherein H may be replaced by an ion elected from the group consisting of elements in the groups III-VIII.

5 ~~8. 10.~~ The material according to any of the preceding claims, additionally containing intercalated or interstitial ions, atoms or molecules, selected from the group consisting of alkali metals, alkaline-earth metals, transition metals, elements belonging to groups III-VIII and any organic donors or acceptors.

10 ~~9. 11.~~ The material according to any of the preceding claims exhibiting a substantially circular cross-section.

~~10. 12.~~ The material according to any of the preceding claims, which is superconducting.

15 ~~11. 13.~~ The material according to any of the preceding claims, which is metallic or semiconducting.

20 ~~12. 14.~~ A method for the production of a material according to any of the claims 1 to ⁹~~11~~, which comprises the steps of (i) mixing of the individual constituent elements, (ii) heating in a sealed container under reduced pressure, (iii) heating above a temperature of 1000 C or more for any duration of time.

⁹~~13. 15.~~ The method according to claim ~~11~~, wherein the elements themselves are replaced by compounds of those elements such as MoS₂ for example.

25 ~~14. 16.~~ Use of a material according to any of the preceding claims in electronic, chemical, optical or mechanical applications.

¹¹~~15. 17.~~ The use of a material according to any of the claims 1 to ~~13~~ as a catalyst in dry form or in suspension or as a catalytic component.

30 ¹⁴~~16. 18.~~ The use according to claim ~~16~~, wherein said use of said material is selected from the

group consisting of a use in a field-emission device, in a superconducting application, in a proximity-coupled network, in a quantum interference network, in devices incorporating said material in 2-, 3-, 4- or multi-terminal configuration, and a use for enhancing electrical, optical, magnetic, mechanical and tribological properties of polymers and glasses by incorporating said material in said polymers and glasses.

¹⁷
~~19~~ The use according to claim ¹⁴~~16~~, said material being used as a lubricating agent, optionally in combination with one or more further compounds, in particular oils.

¹⁸
~~20~~ A method of varying the material characteristics of a material according to any of the claims 1 to ¹¹~~13~~, said method comprising the steps of selecting composition parameters y and z, and/or incorporating dopants or substituents in said material.

¹⁹
~~21~~ An electric device comprising at least one material or material bundle arranged on a substrate, said material being a material according to any of the claims 1 to ¹¹~~13~~; and at least one contact arranged on said substrate and passing over said at least one material or material bundle, said at least one contact being connected with or connectable to circuitry of the device.

¹⁹
~~20~~ The device of claim ~~21~~, said device detecting physical or chemical influences acting on said at least one material or material bundle and/or said at least one contact.

²¹
~~23~~ The device of claim ²⁰~~22~~, said device being adapted to detect physical or chemical influences selected from the group consisting of influences due to molecules attaching to and/or coming into contact with said at least one material or material bundle or said contact(s), light of different wavelengths, and mechanical influences.

²²
~~24~~ A method of arranging a material according to any of the claims 1 to ¹¹~~13~~ in a electric device, said method comprising the steps of

arranging at least one material or material bundle on a substrate;
 providing said at least one material or material bundle with one or more contacts, at
 least one of said one or more contacts being in connection with or connectable to
 circuitry of said electric device.

5

~~23~~~~25~~. An array comprising

at least one material or material bundle, said material being a material according to any
 of the claims 1 to ~~13~~¹¹, said at least one material or material bundle being provided on a
 substrate, the length axis of said at least one material or material bundle extending
 essentially non-parallel to said substrate,

said at least one material or material bundle being provided with a molecule on the end
 distant from said substrate.

~~24~~~~23~~

~~26~~. The array of claim ~~25~~²³, wherein said at least one material or material bundle is attached
 to said substrate or attached to a template arranged on said substrate.

15

~~25~~~~23~~

~~27~~. The array of claim ~~25~~²³, wherein said molecule is attached via a particle, preferably via a
 gold particle, to said at least one material or material bundle.

~~26~~

~~28~~. Use of an array according to any of the claims ~~23~~²³ to ~~27~~²⁵ for detecting a binding of a
 molecule to said molecule provided on said at least one material or material bundle.

~~27~~

~~29~~. A method of arranging an array, said method comprising
 providing at least one material or material bundle, said material being a material
 according to any of the claims 1 to ~~13~~¹¹,
 arranging said at least one material or material bundle on a substrate or on a template
 on a substrate, the length axis of said material or material bundle extending essentially
 non-parallel to the surface of said substrate and/or said template on said substrate, and
 attaching a molecule to the end of said at least one material or material bundle remote
 from said substrate.

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28. Use of a material according to any of the claims 1 to ^M13 for electric applications, said material being connected to or integrated in electric circuitry.

29

29. Material according to any of the claims 1 to ^M13, said material being a nanowire, nanorope, nanorod, whisker or needle provided on one end thereof with a molecule.

30

30. Material according to claim ²⁹31, said material being a sensor.

31

31. Composition comprising a material according to any of the claims 1 to ¹¹13 and one or more materials selected from the group consisting of superconducting compound, lubricating compound, oil, polymer, glass, and gaseous compound.

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